Operation of the ILLINOIS STATE GEOLOGICAL SURVEY

by M. M. Leighton

ILLINOIS STATE GEOLOGICAL SURVEY
CIRCULAR NO. 126

STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, *Director*

DIVISION OF THE

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Natural Resources building, especially designed and constructed to house the offices and laboratories of the State Geological Survey and the State Natural History Survey

NATURAL RESOURCES
BUILDING

ERECTED 1939

TO SERVE THE GEOLOGICAL AND NATURAL HISTORY SURVEYS. THE GEOLOGICAL SURVEY WAS ESTABLISHED IN 1851 AND RE-ESTABLISHED IN 1905. THE NATURAL HISTORY SURVEY ACTIVITIES DATE FROM THE STATE NATURAL HISTORY SOCIETY OF 1862, THE OFFICE OF STATE ENTOMOLOGIST OF 1867 AND THE STATE LABORATORY OF NATURAL HISTORY OF 1871. BOTH SURVEYS WERE ORGANIZED FOR RESEARCH AND EXTENSION PURPOSES AS AN AID TO THE DEVELOPMENT AND CONSERVATION OF THE RICH NATURAL RESOURCES OF THE STATE OF ILLINOIS. THIS BUILDING WAS CONSTRUCTED TO PROVIDE INCREASED FACILITIES FOR THE EMPLOYMENT OF MODERN SCIENCE IN FURTHERING THESE OBJECTIVES.

ERECTED IN CO-OPERATION
WITH THE
UNIVERSITY OF ILLINOIS

INSCRIPTION IN FOYER

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Operation of the Illinois State Geological Survey *

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INTRODUCTION

THE SIMILARITY between a modern state geological survey and one in the early 1830's is indeed slight. The advancement that has taken place is comparable to the developments of the country.

There is, of course, an unmistakable relationship between the recent climacteric expansion of industry and the activities of a modern state survey. Industry, today, is built upon a great multiplicity of resources. The modern state geological survey aids in revealing the secrets of the earth needed by industry.

The earth has always been the mother of the human family, and as the wants and needs of mankind have grown, this relationship has become more intimate. Science has been playing a major role in late years. It has been responsible for the growing complexity of our economic pattern and for simultaneously increasing our ability to discover and develop the necessary resources. It is no small wonder that the revolutionary developments of industry should be paralleled by revolutionary developments in resource studies.

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* Modified from an address presented before the faculty and graduate students of the Departments of Geology of the University of Chicago, March 7; of Harvard University, April 22; of Columbia University, April 25; and of Yale University, April 26, 1946.

IMPORTANCE OF NATURAL RESOURCES

There is nothing more essential than our natural resources. They constitute the foundation for our well-being, the means for our protection, the hope of our future. What career can promise more fruitful service, what profession can invite greater devotion than that which makes scientific inquiry into the hidden resources of this planet!

Someone once said, "Tell me what your resources are and I shall tell you what your society is."

The more we ponder this statement the more we feel its force. The resources of every region make an impress upon its people—the geographic location, topography, climate, soil, minerals, water, and human culture. We recall those regions which have much and those which have little. We picture their wealth or their poverty; their attraction for men of ability on the one hand, or their residual population who are content to live on small margins on the other hand; their progressive type of civilization or the lack of such development, either keeping the people primitive or sending the nation down the road to decay.

Of course it cannot be assumed that the mere existence of resources will insure their development and utilization. Our country was inhabited by the Indians for thousands of years without their having developed its resources, and there are some other countries whose people are content with, or are mentally confined to, their traditions. Instead, then, of saying, "Tell me what your resources are and I shall tell you what your society is," we might express this thought: "Tell me what can be *done* with your resources and I shall tell you what your society can become." If there is need to suggest a motive for state geological surveys, this is one.

PREPARATION IN 1930 FOR A NEW RESEARCH PROGRAM

PREVIOUS to 1930 the Illinois Survey had practiced good geological survey orthodoxy. It did areal geologic mapping, studied the resources of the various coal beds, searched for structures favorable for oil and gas accumulation, surveyed its deposits of clay and shale and had them tested, sought out raw materials suitable for the manufacture of lime and cement, assembled information on outcrops of limestone and deposits of sand and gravel for road building and had samples of these analyzed and tested, carried out studies of groundwater resources and assisted in their exploration by furnishing logs and reports, cooperated with the State Highway Division on their geological engineering problems, and did many other things which an organization of geologists can do in furnishing general information on the geological resources of a State.

You will note that I mention the year 1930. That was a notable year for the Illinois Survey. We celebrated our Quarter Centennial, and our staff prepared a program which, instead of stressing the accomplishments of the Survey during its twenty-five years of history, emphasized the State's future needs.

In formulating this new program we were very conscious of the fact that technology in all lines of industry had advanced greatly since the early 1900's. New uses for mineral substances had developed, specifications for old materials were changing and becoming more exacting, and manufacturing, chemical engineering, metallurgy, the construction industry, processing plants, engineering developments, agriculture, and other phases of our industrial life had become of such importance

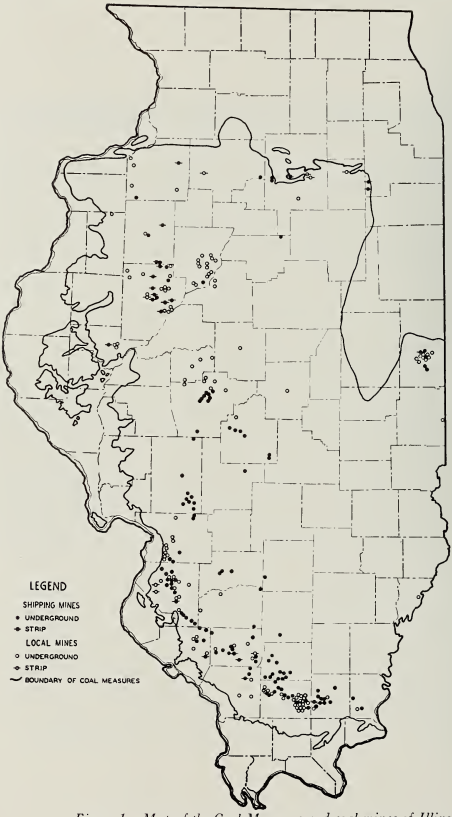


Figure 1. Map of the Coal Measures and coal mines of Illinois

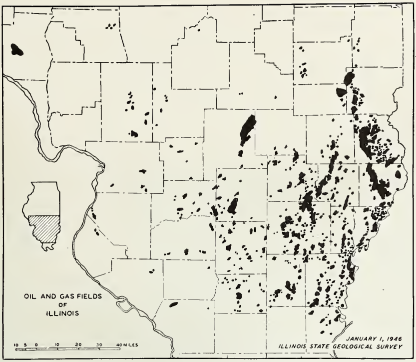


Figure 2. Oil and gas fields of Illinois

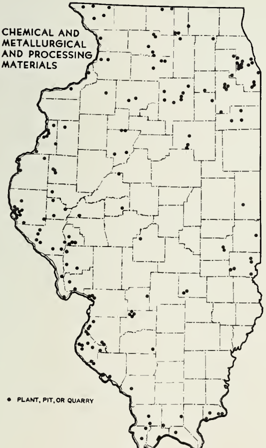
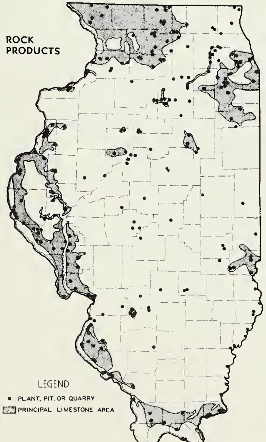


Figure 3. Mineral plants that produce chemical, metallurgical, and processing materials



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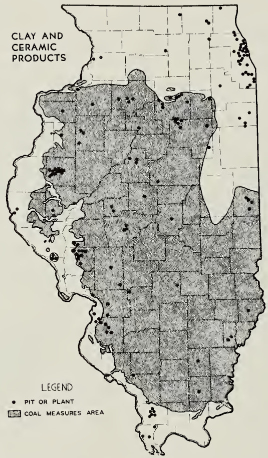


Figure 5. Plants that produce clay and ceramic products

that it was imperative that the State Geological Survey employ the new powers of modern science to learn in detail the geology of the State, the composition and properties of its resources, how these could be improved, what new uses they might have, and what the mineral economics of the Illinois market area were. The scope of these resources is shown by the maps in figures 1, 2, 3, 4, and 5.

With such a program carefully organized, the Legislature of Illinois in 1931 provided the necessary funds to bring together an enlarged staff of geologists, chemists, physicists, and a mineral economist, and to set up new laboratories in temporary quarters furnished by the University.

THE NEW NATURAL RESOURCES BUILDING

Within six years, in 1937, the Geological Survey and a sister biological organization, the Natural History Survey, were prepared to request and justify the appropriation of funds for a new Natural Resources Building to house the two surveys. This building was constructed and equipped at a cost of about $800,000, and it was dedicated with appropriate ceremonies before a large delegation of distinguished guests on November 12, 1940. By March 1941, all of our laboratories were operating, just nine months before the entrance of the United States into World War II.

We had not contemplated that our laboratories would serve the nation in war research but it was not long before one of them was given over to that purpose, and later three others were so engaged.

These facts have their lesson. Once well equipped research facilities become a reality, their usefulness extends far beyond that which one can contemplate in the beginning. The fact that they did fulfill unexpected functions during the war suggests that they may also produce unexpected results in time of peace.

The Geological Survey's portion of the structure is an entity within itself, having 32 offices, a library, 10 geological laboratories, 15 chemical laboratories, 2 drafting rooms, 4 photographic dark rooms, 1 blueprinting room, 2 grinding rooms, 7 storage rooms, and 6 service rooms for mailing, for receiving freight, for furnishing distilled water, compressed air, and vacuum, and for receiving water, gas, steam, and electric current.

The geological laboratories provide for the study of paleontology and stratigraphy, micro-paleontology, paleobotany (fig. 6), subsurface geology, coal petrography, clay mineralogy, clay technology, industrial minerals, and the physical properties of rocks.

Figure 6. The paleobotany laboratory

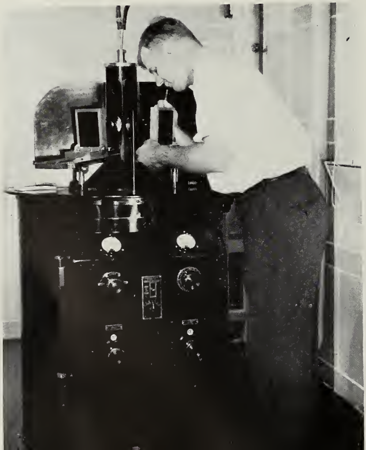


Figure 7. The x-ray diffraction unit in the x-ray laboratory

The chemical laboratories are equipped for coal analysis, nitrogen determinations, rock and brine analysis, oil and gas analysis, micro-analysis, analytical research, study of the chemical nature of coal, chemical study of industrial minerals, research on the chemical utilization of fluorspar, x-ray diffraction work (fig. 7), and spectrography.

The storage rooms provide for the systematic filing of paleontological collections, well-cutting samples, rock and mineral samples, chemicals, and publications.

A garage (fig. 8) at the rear of the building houses the motor vehicles, provides for their repair and servicing, has a special machine shop for the construction of research equipment which cannot be purchased on the open market, and affords storage space for publications and well-cutting samples.

Figure 8. The garage and geological storage at the rear of the Natural Resources building

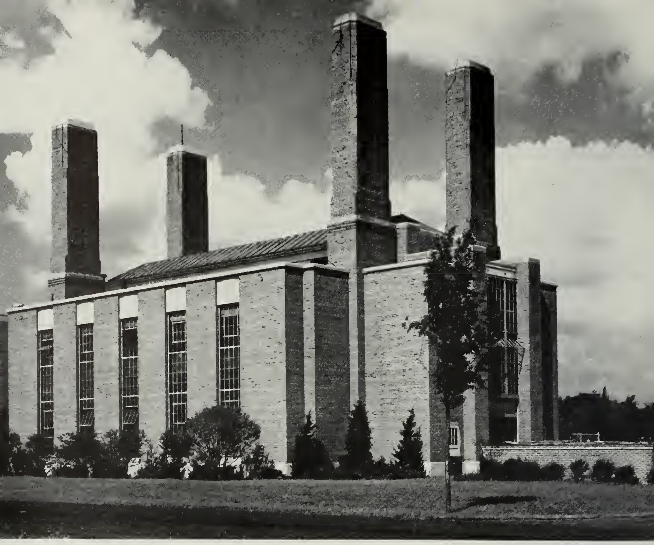


Figure 9. Geological Survey's Applied Research Laboratory

THE APPLIED RESEARCH LABORATORY BUILDING

A NEW applied research laboratory building (fig. 9) was also constructed and equipped as a separate structure, near the University Power Plant, in 1940, at a cost of about $150,000. It is a two-story building with a large central well open to the roof and is readily adaptable to new research projects as they come along. It serves for large-scale experimental studies of coking, briquetting, coal preparation, and combustion characteristics of the State's coal resources.

SCIENTIFIC AND TECHNICAL PERSONNEL

THE RESEARCH staff comprises 72 scientists and technicians, qualified for studies in fundamental geology, economic geology, mineral technology, certain phases of organic chemistry, physical chemistry, and physics, and for studies in mineral economics.

Specifically, the scientific and technical personnel include at this time 32 geologists, 13 chemists, 2 chemical engineers, 2 physicists, 1 petroleum engineer, 1 mining engineer, 2 mechanical engineers, 1 mineral economist, and 18 research and technical assistants.

Of those above the grade of research assistant, 41 percent have doctor's degrees, 38 percent have master's degrees, and 21 percent have bachelor's degrees with varying training and experience beyond that level. Most of the research assistants have bachelor's degrees.

The work of this group is supported by a full-time librarian, a secretarial and clerical force of 18 persons, an editorial staff of 5 people including draftsmen, also a photographer, an instrument designer, and two automotive mechanics. The entire staff now totals 100 persons.

THE ORGANIZATION PATTERN

JUST AS it is essential for a Geological Survey to have physical facilities and a staff, so it is essential to adopt the proper organization pattern. The pattern which we have found to work well is shown in the chart (fig. 10). It will be observed that three major fields of research are covered:

Geological resources
Geochemistry
Mineral economics

In addition, the Survey maintains a program of Educational Extension.

It will be noted from the chart that the geological resources section comprises the following divisions: coal, oil

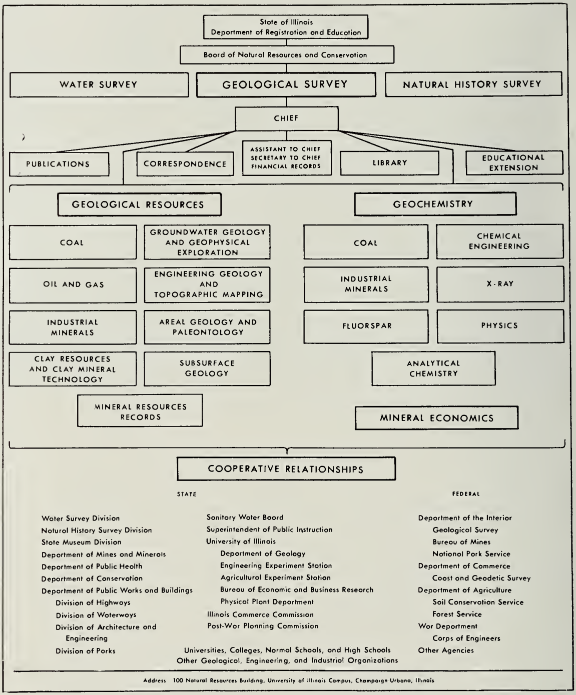


Figure 10. Organization chart of the Illinois State Geological Survey

and gas, industrial minerals, clay resources and clay mineral technology, groundwater geology and geophysical exploration, engineering geology and topographic mapping, areal geology and paleontology, subsurface geology, and mineral resources records.

The geochemistry section includes the following divisions: coal, industrial minerals, fluorspar, chemical engineering, x-ray, physics, and analytical chemistry.

The mineral economics section is devoted to the portrayal of the economic picture of production, distribution, and consumption of Illinois minerals, and to the recording, analysis and publication of annual statistics.

The program of educational extension has two major objectives: (1) to provide popular interpretations of the scientific information obtained by the Survey in the form of educational pamphlets, press releases, lectures, and exhibits, (2) to provide field conferences for high school science teachers, and sets of Illinois minerals, rocks, and fossils for high schools.

The coordination of these diverse sections is a very important matter and is accomplished through the directing heads of these sections and by emphasizing the principle that the interests of research and service are paramount and cross all administrative boundaries. Nature recognizes no boundaries of any sort and therefore research of natural subjects cannot.

I wish to pursue this thought a little further. Universities train geologists most effectively when the curriculum freely crosses departmental boundaries, and the same holds true for chemists, physicists and other specialists. Later when they come to us to prosecute research, we re-emphasize the need for cooperative effort. Geologists, chemists, and physicists, whose previous experiences have been largely confined to their respective fields must discover anew the possibilities of intimate association in problems that transgress departmental boundaries. The invariable result of close contacts of this kind is the discovery of fundamental information which has intrinsic value in supporting new industrial applications.

KIND AND SCOPE OF STATE SURVEY ACTIVITIES

THE NATURAL functions of any modern state geological survey depend upon the nature of the geology and mineral resources, the extent and character of the industrial development, the work of related agencies, and what remains to be done to provide the information needed for intelligent development and conservation. A geological survey, however, is something more than an agency to solve geological problems. For example, on the one hand topographic mapping, if not completed, must be sponsored, while on the other research is needed on problems of improved or new mineral products, improved recovery methods, or geophysical exploration, to extend the production of wealth from potential resources.

Citizens of the State think of a geological survey as the proper place to obtain all kinds of information regarding earth products and conditions. Their requests help determine the duties and functions of a state geological survey; likewise the kinds of data needed by mining engineers, civil engineers, metallurgists, chemical engineers, ceramic engineers, water supply and sanitary engineers, petroleum engineers, quarry operators, construction contractors, processors, manufacturers, purchasing agents, industrial agents of railroads, teachers, state and federal officials, and others. General information no longer suffices, detailed data are required. This multiplicity of information necessitates a staff of specialists for the research phases of the work and a supporting clerical staff for the handling of those matters which do not require the attention of specialists.

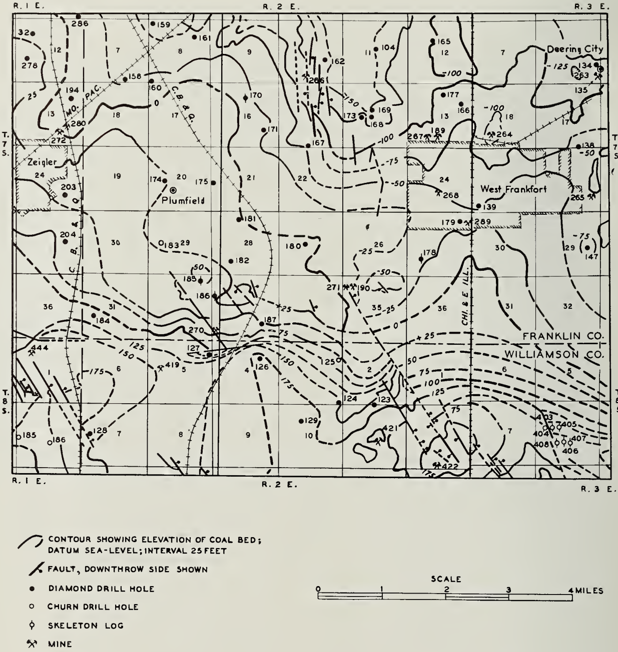
Perhaps the greatest service that a state agency of this kind can render is the furnishing of pertinent information that enables investors to reach sound judgments relative to their enterprises, whether they are initiating new ones or extending old ones.

BASIC OR FUNDAMENTAL RESEARCH

There is abundant opportunity for basic or fundamental research in stratigraphic geology, structural geology, paleontology, mineralogy, sedimentation, geomorphology, geochemistry, geophysics, economic geology, and mineral economics.

Some of the problems which have been recently or are now being studied by the Illinois Survey and which may be mentioned as examples are: state-wide studies of stratigraphy and paleontology of geologic systems or parts of systems; regional studies of the geological column; paleo-physiography such as the pre-Pleistocene physiography of the State; regional studies of geologic structure such as the structure of the Illinois basin, special paleontologic studies as for example the Pennsylvanian fusulinidae or the plant spores of the coal beds; the petrology of coal, the chemical nature of coal, the moisture retaining properties of the banded ingredients of coal; the mode of occurrence and genesis of the zinc and lead deposits of northwestern Illinois; the clay mineral composition and particle-size distribution of the clays and shales of the State, the crystallochemical constitution of clay-type minerals with reference to their properties, organic absorption properties and base-exchange characteristics of clay minerals; the physical properties of ground quartz sand and amorphous silica (tripoli); viscosities of silicate melts (CaO-MgO-Al_2O_3-SiO_2); and studies in organic fluorine chemistry.

Quite aside from the contributions made to science by these undertakings, the value of which no one would deny, their value to applied research is so great that they can be fully justified, even when attacked by the most practical critic. I shall illustrate this in the following discussion of applied research and its benefits. It is to be noted that applied research also brings to light fundamental information of great value. The two are in some instances inseparable.



ILLINOIS STATE GEOLOGICAL SURVEY

Figure 11. One of the Survey's resource maps of No. 6 seam coal in southern Illinois showing the altitude, the geologic structure, and the datum points.

APPLIED RESEARCH

Coal

In the field of coal resources applied research follows several lines.

(1) Mapping of the commercial coal beds on the basis of sea-level datum.

The elements in this enormous work are: the assembling of thousands of drill-hole records, well-cutting samples, and diamond-drill cores; the stratigraphic study of these and the recognition and correlation of all key strata including the coal beds; the instrumental determination of the location of the drill holes and their surface elevations; the contouring of the structural position of the coal beds of commercial thickness (fig. 11); the mapping of faults, "cut-outs," coal partings and such other geologic features as must be taken into consideration; proper sampling of the coal and chemical analysis of the samples; and finally the description, illustration, and tabulation of all pertinent information in such a way as will provide, insofar as possible, a natural picture of the geological conditions and a basis for analyzing and appraising those engineering and economic aspects as enter into the consideration of tracts for exploration and development.

Figure 12. Two of the banded ingredients of Illinois coal: V=vitrain; C=clarain

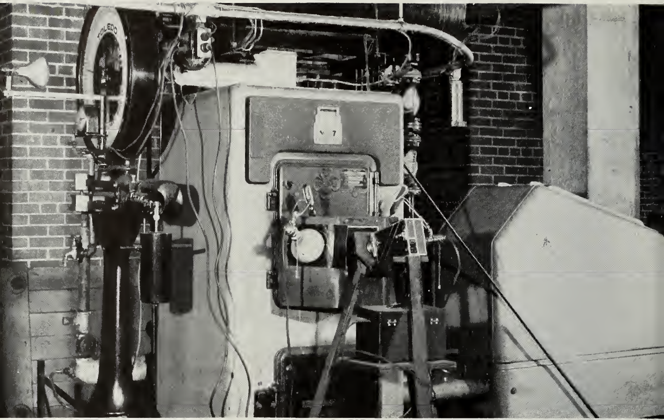


Figure 13. One of the combustion stokers and furnaces, equipped for experimental operation and recording

It is readily appreciated that the geological information and the structure maps resulting from this work also have their value to the oil fraternity and to geologists interested in fundamental problems of the science.

(2) The study of the properties of the coal ingredients.

This is a petrographic, physical, and chemical study of the coal ingredients (fig. 12)—vitrain, clarain, durain, and fusain—that is relatively new and not fully developed in coal geology. It has already resulted, however, in new fundamental concepts of moisture retention and oxidation reactions, as influenced by particle size, which information throws new light on spontaneous heating and deterioration of stock piles of coal, combustion efficiency, coking, and new uses for coal as a raw material in the chemical industry.

(3) Combustion studies of unprepared and prepared stoker coals.

Stoker manufacturers and engineering laboratories have done much experimental work on stoker devices for the efficient

and smokeless combustion of coal, but they have done little systematic work on what constitutes a good stoker coal and on specifications for its preparation. In consequence, therefore, we began an extensive study a few years ago of the combustion behavior of Illinois stoker coals as influenced, among other things, by rank of coal, particle size, banded ingredients, moisture content, ash content, and sulphur content (fig. 13). This work is jointly handled by a mining engineer who is well versed in the geology of coal and a mechanical engineer who is a specialist in combustion.

(4) Research on metallurgical coke.

The steel industries of the Chicago and St. Louis districts have required normally about 12 million tons annually of both low-volatile and high-volatile Appalachian coal for the manufacture of metallurgical coke, and in war-time up to 18 million tons. This peace-time haulage practice was obviously a maladjustment, geographically speaking, and especially was this true in wartime, and so we proposed to the War Production

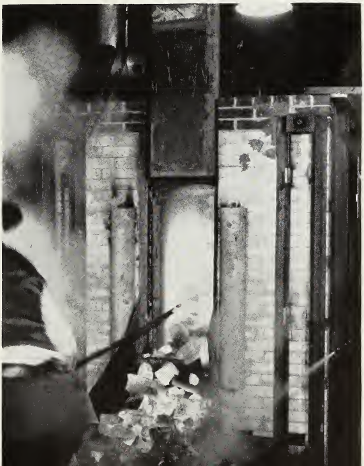


Figure 14. Pulling a charge of coke from the Survey's experimental oven

Board a research project, which it approved, to experiment with low-sulphur high-volatile Illinois coals as a substitute for high-volatile eastern coals.

An experimental oven (fig. 14) having a capacity of 500 pounds of coal was designed and constructed by our Geochemical Section, and it may be said, in credit to its designers, that it duplicates closely the results of commercial ovens and has recently been copied by a number of coke research laboratories. Within four months from the beginning of our experimental work a coke company in Illinois changed its operation to the extent of using approximately 65 percent Illinois coal. This practice resulted in the release of railroad rolling stock equivalent to about one freight train for the entire period of concentrated east-west military transport against Japan. Whereas in 1943, no Illinois coal was used in the production of metallurgical coke, approximately 50,000 tons per month, as of February 1946, were used. At present three steel plants are cooperating with us (fig. 15).

Figure 15. A battery of commercial coke ovens at the plant of Koppers Co., Inc. at Granite City, Illinois, with whom the Survey has cooperated

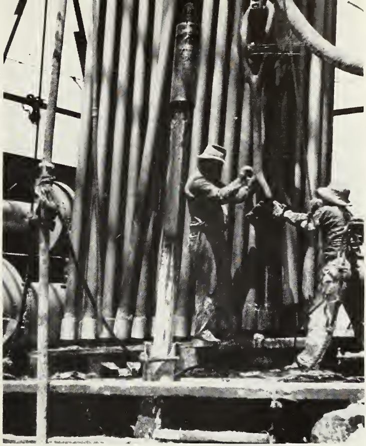


Figure 16. Corner of a rig floor of a drilling oil well in Illinois. The Survey has obtained cutting samples from thousands of such wells.

Oil and Gas

(5) Classification of the oil and gas possibilities of the State.

Following the discovery of oil in the Michigan basin in 1928, the Illinois Survey began the preparation of a classification map of the oil and gas possibilities of Illinois which was completed and made available in 1930 (fig. 17). This map was based on several criteria, the most important of which were the extent of the Lower and Upper Mississippian formations and the faulted structure of southern Illinois. The Illinois basin was given rank No. 1 as having the best oil possibilities, and the rest of the State was classified in three other categories: No. 2 for the area having moderately favorable oil possibilities, No. 3 for the area having slightly favorable oil

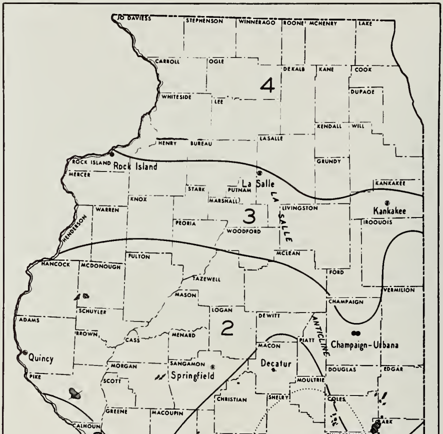


Figure 17. Classification map of the oil and gas possibilities in Illinois and existing pools. The classification of areas was made in 1930, seven years before the first discovery in the Illinois basin.

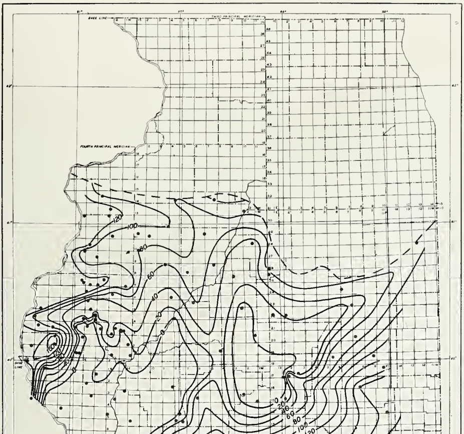


Figure 18. Map showing thickness of the Devonian formations below the Kinderhook-New Albany shale and above the base of the Dutch Creek sandstone

possibilities, and No. 4 for areas of negligible oil possibilities. The old fields in southeastern Illinois had their heyday in 1905-10, and for many years after that the oil industry had practically no interest in Illinois. However, new concepts of oil occurrence in geological basins and the appearance of our classification map stimulated new interest in Illinois, and as a result leasing became intensive in 1936 and the first discovery was made in 1937. Since then, more than 700 million barrels of new oil have been produced, and more than 99 percent of this has come from our area No. 1 in the Illinois basin.

(6) Stratigraphic, lithologic, structural and isopach studies.

The major objective of our oil and gas investigations is to provide geologic data that will lead to the finding of new producing horizons, new fields, and extensions to old fields. This work consists primarily of stratigraphic and structural studies of certain formations over large areas (fig. 18), as well as detailed stratigraphic, structural, and lithologic studies of the whole column in limited areas. For example, we have prepared maps showing the regional subsurface structure, on the base of the New Albany shale, on the lower Glen Dean limestone of the Chester and on the top of the Lower Mississippian. Also isopach (thickness) maps have been made, such as that of the Devonian-Silurian system below the New Albany shale.

(7) Studies of conditions governing secondary recovery.

Beginning in 1936 the Survey has continuously advocated, in publication and otherwise, water-flooding for secondary recovery of oil in certain Illinois fields. This has been no small factor in the water-flooding operations now in progress in Illinois. The Survey is also continuously providing necessary geologic information and counsel for its successful operation.

The results of this effort have been most gratifying. A total production of oil due to water-flooding in three areas in the State (Patoka pool, Marion County; Siggins pool, Cumberland County; Clay City-Dundas-Boos area in Clay, Wayne, Richland and Jasper counties) as of January 1, 1946, is estimated to be 5500 barrels per day, or nearly 3 percent of the State's total.

(8) Collection and reporting of development data.

From the beginning of the new oil field developments, the Survey has collected complete and accurate data on current drilling insofar as this is possible. Two scouts who are assistant geologists are employed for this purpose. One of them scouts a district in the State and attends weekly meetings of the Illinois Basin Scout Association where information is exchanged on oil and gas drilling in the whole State. The other scout visits wildcat wells where coring is done to obtain core samples and geologic descriptions of the entire cores. He also collects samples of oil, gas, and brine when that is desired. Among other things this work supplies most of the data needed for our monthly drilling report which provides the industry with up-to-date current information. In addition the Survey prepares and publishes an annual report on the oil and gas developments within the State.

Industrial Minerals

(9) Study of the properties of fine silica.

Illinois is probably the largest producer of fine silica (produced from quartz sand) (fig. 19) and tripoli. Even so, the industry has been hampered by the lack of fundamental information on particle size, oil adsorption, specific surface, abrasiveness, and particle structure. Researches are in progress to obtain this information.

(10) Study of the "soundness" of Illinois limestones and dolomites.

Large tonnages of limestone and dolomite are used for railroad ballast and for filter stone for sewage disposal plants. In all of these cases "soundness" is a requisite property. Erroneous and conflicting ideas have existed regarding soundness of various types of such stones. To remedy this situation the study of the soundness of the State's dolomites and lime-

Figure 19. Plant of the Ottawa Silica Company near Ottawa, 1940

Figure 20. Plant and quarry of Lehigh Stone Company, Kankakee, Illinois

stones is being conducted in cooperation with the State Division of Highways and the Engineering Experiment Station, University of Illinois. Interesting results of value to the stone industry are being obtained. For example it was found that the porous reef rock of the Chicago area has superior soundness to the other types of dolomites in this area. Figure 20 shows a large limestone plant in Illinois.

(11) Survey of resources of agricultural limestone.

Illinois is the country's largest producer and user of agricultural limestone. In 1944 more than 4 million tons were used, and 121 individual quarries reported production. The industry has not yet reached its production peak, as evidenced by the numerous inquiries for information regarding potential quarry sites. Resource studies are being made to supply the needed information.

(12) Study of resources of building stone.

At present there is only a relatively small production of native building stone in Illinois, largely because the possibilities of the State are not well known. Researches are being

conducted to determine the merit of Illinois stones for this purpose and their potential architectural acceptance.

(13) Very few producers of crushed stone have developed a comprehensive knowledge of their deposits bed by bed and of special uses for certain layers of their stone. A few years ago we began a study of the chemical stratigraphy of our stone quarries and principal outcrops, taking samples bed by bed and analyzing them. The result has been the discovery of commercial thicknesses of stone for which there is a market in the chemical industry, and a report on high purity dolomite published during the War. This emphasizes the value of detailed stratigraphic work leading to the division of formations, where possible, into members of consistent lithologic character and physical and chemical properties.

(14) Illinois is one of the largest producers of sand and gravel. Most of the reconnaissance mapping of these resources has been completed, but we have continuous calls for detailed information, especially in connection with the construction of farm-to-market roads and the selection of new sites for sand and gravel plants which will meet special specifications such as fine-grained molding sand for certain types of castings.

(15) One product of our group plan of research by geollogists and chemists is the bulletin published by the Survey on the resources of wool-rock and the chemistry of its manufacture. During the war requests were received from all over the world for this publication and it was extensively quoted in a recent bulletin of the Geological Survey of Great Britain.

Our work pointed out the need for fundamental research on the viscosities of melts in the system lime-magnesia-alumina-silica. Such work has been undertaken and it is showing the permissible compositions of raw materials for the manufacture of rock wool. These viscosity data are also applicable to many metallurgical processes in which problems of slag formation and handling arise. A high-temperature furnace with accessories for precise control of temperature was constructed especially for this work.

Clay

(16) In 1931 our study of clays and shales was changed to a more fundamental and thoroughgoing approach than the orthodox studies had provided. Microscopic mineralogy and x-ray diffraction were employed to improve the knowledge of these fine-grained variable materials, and the former methods of testing and chemical analysis were each given their appropriate place in the search for comprehensive information. As a result, our study of clays and shales falls into three categories, which are continually integrated with each other.

a. We are continually building up a catalog of the occurrence, properties, and composition of all types of clays and shales in the State. Composition means clay-mineral constituents, particle-size distribution, base-exchange characteristics, and accessory minerals, as well as ordinary chemical composition. Under properties is included such non-ceramic characteristics as bond strength, suitability for filling rubber and properties for other special uses, as well as the usual ceramic properties. The catalog is built up by actual field studies as well as by laboratory investigations. Figure 21 shows a large clay pit in Illinois.

b. The second general field of clay studies is concerned with an effort to determine and evaluate the factors that control properties of clay materials. For example, we endeavor to learn about the factors that produce bonding strength in a clay. We wish to know, for instance, why only certain clays make satisfactory steel ladle brick, and why certain clays develop bad checking when ware made from them is dried. Such studies have permitted us to accumulate a huge fund of information on Illinois clays which has proved to be of tremendous value in the solution of processing problems. Industry continually calls on us for help in such matters. It has enabled us, for example, to aid in the solution of a bad lamination problem in an Illinois face brick plant. In another case it opened up a new and unexpected use for certain clays. For example, a few years ago we were able to show a refractory

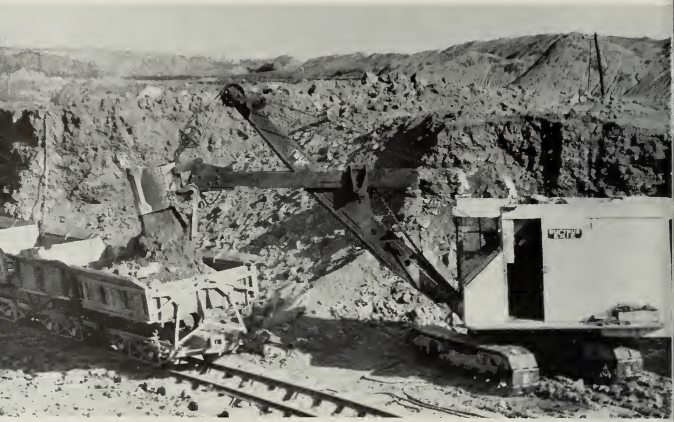


Figure 21. Mining fireclay at the pit of the Illinois Clay Products Company at Goose Lake, Illinois

brick manufacturer that a clay he had discarded for many years in the overburden of his pit was valuable for rebonding molding sand, and this clay now demands a higher price than any other of his products. In addition such fundamental studies form a basis for investigations into the possible ways and means of altering or beneficiating Illinois clays so that they will be suitable for new markets. Our approach is by petrographic x-ray analysis, particularly of the clay-mineral components, which reveals the mineral species and the molecular structure that controls the properties of a given clay-mineral.

c. The third general field of activity might be classed as utilization studies. In this our objectives are improvement in the quality of present products made from Illinois clays and the development of new uses by improving, changing, or controlling properties. This work is largely an outgrowth of the fundamental studies just mentioned. For example, some years ago we conducted a study of the factors that controlled the variation of the bonding properties of clays used in foundries

for rebonding molding sands. Out of this research there grew a new promising way of making a light weight clay product.

(17) During the war the Industrial Minerals Division of our Geochemical Section was engaged in research on the extraction of alumina from clays. This was an excellent example of cooperative research within our own organization; the alkaline sinter work was carried out under the direction of our physical chemist, petrographic work was done in our Geological Resources Section, and x-ray analysis was done in our own x-ray laboratory. This research provided new information of fundamental value in the operation of pilot plants by federal agencies and others and in the interpretation of results.

(18) In another project involving the cooperation of the Geochemical Section with the Geological Resources Section, the composition and base-exchange characteristics of Illinois clays and shales and the relations of these characteristics to their ceramic and other properties are being studied.

The objectives of this project are of two distinct sorts:

a. Fundamental studies of the composition and crystallochemical constitution of the various clay minerals.
b. The practical identification of types which are responsible for various useful properties of natural deposits.

The coordinated program has produced important contributions on the composition, properties, and occurrences of the illite group of clay minerals, and on constitution, water affinities, base-exchange characteristics, and organic adsorption properties of the montmorillonite group of minerals.

We are currently concerned with the influence of high temperatures on the various clay crystallizations—an approach that is of interest not only in ceramics, but also in the field of catalytic operations upon petroleum. In this interest, we are being motivated by the prospect that in the future, petroleum will become more and more a chemical raw material.

Fluorspar Resources and Fluorine Chemistry

(19) Two counties in extreme southern Illinois, together with an adjacent part of Kentucky, comprise the principal fluorspar-producing district in the United States (fig. 22). It is well known that fluorspar is necessary in the production of steel and aluminum, in oil refining, and for certain processing operations and chemical products. During the war the Survey continuously maintained a field party of from 1 to 3 men in southern Illinois for geologic studies directed towards discovering additional fluorspar resources. This work was done in cooperation with U. S. Geological Survey and U. S. Bureau of Mines.

A further study of the paragenesis of the fluorspar deposits is being made with the hope that information can be gained that will aid in resource studies. In addition plans are being formulated to explore the use of various geophysical methods for location of ore bodies in this area.

Figure 22. Loading fluorspar ore underground on the 600-foot level, Rosiclare Lead and Fluorspar Mining Company, Rosiclare, Illinois

Figure 23. Fluorine research laboratory

(20) About 1930 the development of the organic fluorine refrigerants known as the Freons gave an impetus to the study of organic fluorine compounds. The Illinois Geological Survey began looking into this field in 1933, and started experimental work in 1935. The reason for this is that a chemical market supports a more steady production. By the time the war started, we had a valuable backlog of experience and well-equipped laboratories which made it possible for us to undertake highly confidential research work on organic fluorine compounds for the armed forces (fig. 23). Although the nature of the work carried out in this laboratory cannot be disclosed, fluorine chemistry played an important part in the development of "bug" bombs, special synthetic rubbers, the atomic bomb, synthetic cryolite, high octane aviation gasoline, dielectrics, etc.

The research program is directed toward obtaining fundamental information, but we cooperate with industries, and have been able to supply a number of special organic fluorine compounds which have been requested of us. In turn, certain industrial laboratories have indicated their willingness to make tests on these compounds, such as, for example, the testing of insecticidal power.

Zinc and Lead Resources

(21) The necessity of an adequate supply of zinc and lead during the war caused a renewed interest in the old producing area in northwestern Illinois (fig. 24). The Survey established an office in Galena, and has continually maintained a staff of from two to six people in that area. Our work has combined the detailed mapping of the geology and the study of the occurrence of the ore. The U. S. Bureau of Mines carried on a test-drilling program at locations jointly recommended by the U. S. Geological Survey and the Illinois Survey. As a consequence of this drilling, areas containing more than 1½ million tons of inferred zinc ore have been outlined.

Figure 24. Drilling blast-holes in the mining of zinc and lead ore, Ginte Mining Company, near Galena, Illinois

Our geologic work has also led to a new concept of the geologic causes for the location of the ore deposits which promises to be a useful guide in locating areas favorable for prospecting.

We are also investigating the merits of various geophysical methods in locating ore bodies in this area.

Geology of Groundwater

(22) A very important activity in the field of groundwater is the preparation of geological reports of groundwater resources and conditions in response to inquiries from municipalities, industries, and individuals. This work is handled in cooperation with the State Water Survey and the Department of Public Health where that is necessary. The volume of reports is large, averaging about ten per week. Reports deal with the geologic formations, conditions likely to be encountered at the given site, a relative evaluation of the geological characteristics of the aquifers, and any suggestions for well design, construction, testing or repairs that might be derived from the geologic considerations. Whenever pertinent, an endeavor is made to follow up reports by counsel and by cooperation in the running of geophysical surveys and logs, in acidizing, and in observing test-wells during drilling and testing.

In addition, areal studies of groundwater geology are made. This work is carefully integrated with our subsurface and stratigraphic studies.

Geophysical Exploration

(23) A large part of our geophysical work is connected with our groundwater studies. The Survey introduced to the water well industry of Illinois the art of geophysical logging. The geophysical logs are run by commercial companies under the supervision of our staff, or with Survey equipment where the holes are not suitable for commercial logging. For the latter purpose a geophysical truck has been built and equipped which is in reality a field laboratory (figs. 25 and 26).

Other geophysical work carried on in connection with groundwater studies consists of salinity-resistivity tests, temperature and current measurements, and pH determinations, in connection with acidizing or other special testing work.

In addition, earth-resistivity surveys are made for the purpose of locating water-bearing sands and gravels in the glacial drift. Such surveys are made in response to inquiries from municipalities, under the plan whereby the Survey supplies the equipment and operator and the municipality supplies the labor. This work has grown into a very important activity.

Figure 25. Geophysical laboratory truck, fully equipped for geophysical logging of water wells and diamond drill-doles

Figure 26. Part of the interior of the Survey's geophysical laboratory

Our geophysical work outside of the field of groundwater consists primarily of: (a) running electrical logs of diamond-drill holes in connection with coal resource studies; (b) making earth-resistivity surveys for locating sand and gravel deposits in cooperation with the State Highway Department; (c) logging of lead and zinc drill holes; (d) fluorescent studies and core analysis for oil; (e) an investigation of the possible use of electrical methods for the location of lead and zinc and fluorspar deposits; (f) investigation of the transmission of radio-frequency electromagnetic waves through earth materials and possible geological application.

Engineering Geology

(24) In the Survey's engineering geology work, the objective is to provide geologic data for the engineer pertinent to his problems. In our work with engineers, our policy is to remain geologists and not to attempt to become engineers, although one needs to recognize the engineer's problems and to provide if possible the geological information needed by him. Our experience indicates that this approach is sound.

Our early engineering geologic work was concerned mainly with highway problems, such as landslides (fig. 27), mud flows, drainage, fills (especially across peat bogs), bridge abutments, and piers and grade separation. Later the emphasis was still on highway problems but also on studies of soils and subsoils that form the subgrades of highways. In addition we were also asked for geologic information for damsites, foundations for heavy buildings, etc. Recently there has

Figure 27. Gap in pavement (surrounded by barricade) effected by landslide

been a steadily increasing demand for information on the geology of damsites and for general water resources and conservation problems. Within the last several months studies and reports have been completed for more than 20 damsites for the U. S. Army Engineers Office in Chicago.

We also work closely with two other branches of the State Government besides the Highway Division in our engineering geology studies, the Division of Waterways and the Department of Conservation.

Soil Mechanics and Clay Mineralogy

(25) As a result of our studies of clay mineralogy and the factors that control clay properties we gradually became interested in the relation of soil mechanics to clay mineralogy. To elaborate briefly on something that we believe is very important, many structures are built on and with "soil" materials, as for example building foundations, subways, bridge abutments, highway subgrades, dams and other structures.

The engineer must know something of the properties of these "soil" materials. Thus he makes some empirical tests, obtaining values to be used in design and hoping that they will tell him how the soil material will act for long periods of time under a variety of conditions. Usually his data are satisfactory but sometimes the bridge fails, the building settles, or the highway goes to pieces, which often means that the material did not act as the engineer predicted it would in his design.

It seems obvious that until we know the basic causes for the variation in certain properties, structural failures cannot be eliminated. The Illinois Geological Survey is about to embark on a project on the relation of the soil mechanics characteristics of earth materials to what might be called clay petrography. In this we will work closely with the University of Illinois, the State Highway Department, and others. We have already carried out some exploratory work with particularly encouraging results.

Chemical Analysis

(26) It might be well to devote a few words to the activities of our Analytical Division. This is a service division which furnishes chemical analyses needed in connection with the research program of the entire Geological Survey (fig. 28). Six major lines of chemical analysis are covered as follows:

Coal and coke analysis
Rock analysis
Oil analysis
Gas analysis
Brine analysis
Micro analysis (organic)

In addition to the service work, this division has the responsibility of developing new procedures or modifying old ones in order to secure desired data. Active cooperation is

Figure 28. Analytical rock and brine laboratory

maintained with the American Society for Testing Materials on specifications and methods of analyzing coal and coke. This work includes suggesting new or modified specifications and analytical procedures, checking those suggested by others, and studying interpretations and applications of data so obtained. It is often necessary to determine certain characteristics of materials to be tested in order to approach better the problem of developing a special test procedure. In this connection we are studying moisture in coal, its nature and determination, effect of oxidation on analytical samples, and special tests such as plasticity of coal as related to coal carbonization.

Aside from the studies on coal, work is being done on methods of analyzing certain types of organic compounds in connection with the fluorine research program. In particular, both micro and macro methods for determining fluorine in synthetic organic fluorine compounds are being studied.

Mineral Economics

(27) The general function of the Mineral Economics Section is to investigate the economic problems of the mineral industries of the State, to assemble and publish data on mineral production, consumption, and movements that will aid in portraying the economic picture, and to cooperate with the other scientific sections of the Survey in the economic evaluation of projects concerned with the mineral resources of the State. To this end, studies are made and reports issued along the following lines:

a. Annual statistical report of mineral production.

b. Commodity studies, such as the competitive position of coal in the Illinois coal market area.

c. Regional economic studies, such as the development of the Chicago industrial district.

d. General studies in mineral economics, such as post-war issues in the petroleum industry.

FURNISHING INFORMATION TO THE PUBLIC

A STATE geological survey must meet its primary obligation of furnishing information to the public. There are two very important aspects of this, one the issuance of publications and the other the direct handling of replies to inquiries by letter, telegram, telephone, or by conference.

If the research program is on an appreciable scale, an editorial setup is necessary, with provisions for scientific criticism and approval and for the customary editing, final drafting, and printing routine.

Answering inquiries through correspondence requires devoted effort in assembling information from the files and the staff, eliminating the non-essentials, and exerting sincere effort to meet the needs of the inquirer. Much of the public evaluation of the survey's service comes from the competent handling of these duties. The best time to justify the survey's existence is day by day in work of this kind.

Another important phase is lending help to teachers and public-spirited citizens in gaining knowledge of the State's resources and their significance to the public welfare. This can best be directed through an educational extension program.

GROWTH OF THE STATE'S INDUSTRIES

NO TWO decades are similar. Industrial and social change is inevitable. New scientific findings constantly bring about industrial changes in production, which in turn require research on resources to meet industry's expanding needs.

The Illinois Geological Survey was established in 1905. In that year the value of the mineral output of the State was approximately $60,000,000. In 1944 it was $334,000,000. The value of manufactures in Illinois in 1905 was $1,400,000,000, while in 1944 according to estimate, it was $10,500,000,000. It is believed that this illustrates unmistakably that industrial expansion and the Geological Survey's research go hand in hand to the advantage of the commonwealth.

PROSPECTS FOR THE FUTURE

Young men and women in geology who are wondering about the opportunities in their chosen career need have no concern as to that matter. I suggest that their concern should be with reference to the breadth of their training in the basic sciences. The geologic study of the earth, in its physical and economic aspects, will require further application of physics, chemistry, and mathematics than heretofore; similarly the biological phases of geology will require more emphasis on zoology and botany. The most vital question of all is, what will give the future geologist the greatest intellectual power of inquiry, analysis, and discovery.

I am confident that both national and state geological surveys will increase in strength. State interests require state surveys, and national interests require national surveys. Both of them serve a great purpose in state and national development, by research, by serving as public archives of valuable resource records, and by disseminating the information secured to aid in the country's further development.

In Illinois, I am glad to say, the leaders in government and in the body politic are conscious of the State's dependence on its resources. Probably no greater evidence is needed of this than the fact that the State has made provision for further laboratory additions to our Natural Resources Building (fig. 29) and for extensions to our Applied Research Laboratory. The large dividends in social and economic development will repay many fold the money invested in laboratories and a staff of creative specialists.

Figure 29. Architect's sketch of the Natural Resources building with proposed wings for the Geological Survey and the Natural History Survey

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